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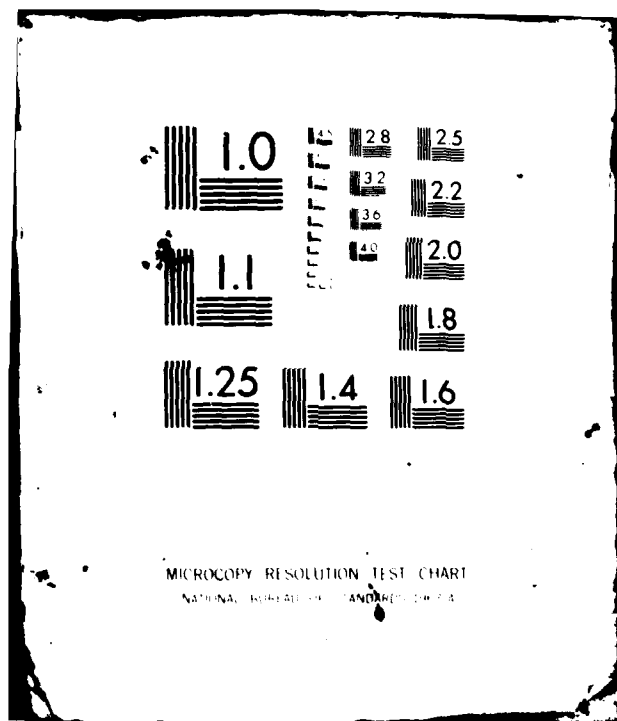
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**TASK ANALYTIC TECHNIQUES:
APPLICATION TO THE DESIGN OF A FLIGHT SIMULATOR
INSTRUCTOR/OPERATOR CONSOLE**

By

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Williams Air Force Base, Arizona 85224

December 1981

Final Report

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**This publication is primarily a working paper.
It is published solely to document work performed.**

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Table of Contents

	<u>Page</u>
I. Introduction	5
II. Objectives	6
III. Review of the Literature	7
Instructional Systems Development	7
The Military and Instructional Systems Development	7
Task Analysis	8
Instructor/Operator Console	12
IV. Application of Task Analytic Techniques	14
V. Recommendations	15
VI. Bibliography	16

Task Analytic Techniques: Application to the Design of a Flight Simulator Instructor/Operator Console

I. Introduction

The purpose of this study was to present findings from a review of literature on procedures related to the application of task analytic techniques to the design of an instructor/operator console. The study did not attempt to evaluate an existing simulator or its instructor/operator console parts, but it did develop suggestions for their improvement generally. These recommendations were made after an extensive review of the literature had been conducted. The study was not conducted for the purpose of designing, theoretically or graphically, a new kind of instructor/operator console; however, the findings may be useful to those involved in the technical design of instructor/operator consoles. The review of literature consisted of an examination and an extrapolation of the many aspects and factors associated with task analysis. An examination was made of the present use of task analysis by the Department of the Air Force and the military sector in general.

Emphasis was placed upon Instructional Systems Development (ISD) for the following reasons: (1) since the Air Force developed its first major instructional system in 1965, the systems approach to training has received considerable emphasis within the Department of Defense and in the civilian sector; and (2) task analysis is a major component of ISD.

A special section is devoted to ISD in the military due to the fact that the military has been a prime developer and consumer of instructional design and instructional technology. Some attention was given to the historical growth of the process as well as the rationale for certain aspects of growth. Special emphasis was given to the fact that the military has a specific mission in national defense and space exploration which requires efficiency and high standards of human performance. Increased efficiency of training simulators resulting from better-designed instructor/operator consoles (IOCs) will come from application of ISD principles.

II. Objectives

The first major objective of this project was to conduct a review of the literature dealing with (1) flight simulator IOCs, and (2) task analytic techniques to determine procedures whereby an IOC may be designed with sufficient regard to information and control requirements of the instructor pilot. The second major objective was to produce a document describing accepted task analytic techniques and how a task analytic technique or techniques might be used in IOC design.

The specific goals that emerged from the major objectives were:

- (1) To review the literature on ISD in order to determine the role of task analysis in this overall design.
- (2) To portray through a literature review the accomplishments of the military in the field of ISD.
- (3) To present recommended principles and techniques for conducting a task analysis.
- (4) To present the present status of the instructor/operator console.
- (5) To make recommendations for applying a technique or techniques to deal with the possibility of improving information and control requirements of the instructor pilot.

III. Review of the Literature

Instructional Systems Development

Instructional Systems Development (ISD) is a planned and organized process for designing efficient training programs. It is a cyclical process involving team effort, and it is goal-oriented and user-oriented. It is a primary function of professional educators and industrial or military trainers.

An instructional development system is both a philosophy and a set of tools. The basic objective of instructional design is to identify the concepts, principles, and skills to be taught so that scientifically validated information about human learning can be applied. Instructional design requires an orderly, sequential program of proficiency goals which are both specific and flexible. The task of designing instruction is not easy. It requires not only an in-depth knowledge of the particular skill to be taught, but also the ability to perceive the skill from each learner's point of view. An instructor should specify the final proficiency requirements in specific observable terms; assess the learner's current repertoire which is relevant to the desired outcome; and design a program consisting of a series of steps from current status to desired proficiency. In some cases it may be necessary to design a preparatory program for those learners whose current repertoires are inadequate.

ISD in the Military

The military has been perhaps the greatest developer and consumer of instructional design. Training effectiveness and efficiency are highly important in the military arena, and considerable emphasis is given to efforts which are intended to increase effectiveness and efficiency. Training programs applied in the context of the ISD approach had not been developed to any large extent prior to the 1950's; however, ISD is an outgrowth of the Systems Approach to Training (SAT). Investigations on learning and instruction were conducted through research in psychological laboratories.

World War II created a need to increase the effectiveness and efficiency of military training. Psychologists were brought into the military and were given the assignment of designing such training. The period represented a dramatic increase in the areas of instructional technology and instructional design.

Briggs (1977) feels that probably the most interesting of all longer-term training is that of aircrew flight training. Psychologists adapted their traditional laboratory equipment to devise selection tests, after which the equipment was further transformed into various types of training devices. After a short period of time, special-purpose equipment was designed to train equipment operators and maintenance personnel. These personnel were taught not only to operate but also to repair and service the equipment. Initial research on the use of film in instruction began during this period. In the military environment, according to Briggs (1977), the validity of training is paramount to the success of a mission; that is, poor instruction yields poor performance.

Many resources are utilized for the design of instruction -- military personnel; civilians employed by the military; and contracts with universities, research laboratories, and private companies. The designer makes important decisions relative to cost-effectiveness. The designer is always aware of the fact that training programs are related to the national defense or space exploration and that they must meet extremely high standards of human performance.

Training begins with the development of individual skills; then groups or crews are trained together. Each person is dependent on the other. Training aids, training devices, and simulators contribute to the learning effort. The command and control structure for learning in the military is direct and firm. Control implies that planned objectives are met and objectives are valid.

Task Analysis

Task analysis is the process of breaking down a task into its component parts. The component parts are referred to as subtasks. After the

subtasks have been identified, precise determinations are made about the skills and knowledges a learner needs to become proficient in performing each subtask.

Task analysis involves the application of scientifically validated principles of human learning to the teaching of concepts, principles, and skills. There are certain advantages that accrue from the use of task analysis: (1) students are taught the best procedures for doing things; (2) nothing irrelevant or erroneous is taught; (3) no gaps exist in the subject matter; (4) material is presented in well-organized instructional units, incorporating the most effective conditions under which students learn; and (5) students are more likely to learn if the material is presented in the correct sequence. Task analysis can be applied to many situations and tasks other than those related to training systems.

There are two broad classes of tasks: action tasks and cognitive tasks. Action tasks, in the majority of instances, involve clearly defined observable steps. The steps can be broken down into subtasks and sequenced. Cognitive tasks are performed mentally, and the activities are generally not observable. Cognitive tasks involve such activities as deciding, evaluating, and discriminating. Some tasks of a cognitive nature are fixed sequence in nature, and they may be described by using a flow diagram, but cognitive tasks that do not lend themselves to a flow chart may be described by outline or narrative form.

The two major kinds of action tasks are fixed sequence and variable sequence. Fixed sequence action tasks may branch and return to the mainstream of action. The absence of the normal feedback is a cue for a different sequence of actions. In some cases, the task has branches and the action may be followed by two or more cues signaling different intervening activities; these action tasks are of a variable sequence nature. Variable sequence action tasks cannot be described completely in a fixed sequence of actions. Generally, variable sequence action tasks do not involve a series of discrete actions elicited by particular cues. The cues are constantly changing, and for this reason the actions resulting therefrom are referred to as variable sequence. Variable sequence action tasks can be described by dividing the task into subtasks and using outlines, narrative descriptions,

and flow diagrams. Usually, one or more fixed sequence subtasks are involved in variable sequence action tasks. It is important to be able to recognize fixed sequence tasks among variable sequence ones.

Flow diagrams are methods of representing fixed sequence tasks in schematic or diagrammatic form. Flow diagrams assist in visualizing the structure of a task. It is a method for clarifying relationships among actions, cues and feedback. If flow charting were not used, the clarifying of the sequences might become obscure and possibly overlooked. The steps in a task are represented by a set of symbols. The shape of the symbol used depends on the function being performed. The symbols used in flow diagramming have not been standardized; however, the symbols used in computer programming are commonly used.

Davis, Alexander and Yelon (1974) developed a Task Description Checklist that could be used as a summary of steps useful in performing a task analysis. The checklist also provides guidelines for the points at which flow diagrams should be used. The steps are as follows: (1) If you are an expert in performing the task, go directly to No. 2. If you are not an expert, first learn how the task is performed. (2) Break the tasks down into subtasks using action verbs such as operate, decide, ask, lift, etc. (3) Identify those subtasks which are fixed sequence, and describe them using flow diagrams. (4) Do not attempt to describe subtasks which involve preference, taste, or values, and avoid subtasks which cannot be broken down into more discrete steps. (5) Describe all remaining subtasks using either a narrative form or outline. This checklist is a significant guide in performing the task analysis process.

DeVries, Eschenbrenner, and Ruck (1980) did an extensive and intensive study of task analysis for the United States Air Force which resulted in the Task Analysis Handbook. From a comparative point of view, the principles and practices recommended by the researchers cited above coincide precisely with those of DeVries, et. al. (1980)

DeVries and his co-authors begin their study with an overview of ISD and emphasize analysis of the system; definition of education training requirements; development of objectives and tests; planning, developing, and

validating instruction; and conducting and evaluating instruction. Task analysis and its component parts are defined. The DeVries study provides a schematic design of all steps used in task analysis. The study cautions one to be aware of the fact that task analysis may be defined in simple terms, but as a process, it is quite complex. Three key acronyms were introduced in the study: STS or Specialty Training Standard; CTS or Course Training Standard; and PPR or Preliminary Performance Requirement. The STS or CTS constitutes a contract between the Air Training Command and the Wing Command. It specifies what must be taught at the appropriate level in each course.

The DeVries study emphasizes the importance of preliminary performance requirements, identification of subtasks, identification of supporting skills and knowledges, examination of training standards, converting task performance and task knowledge statements into behavioral requirements, task observation, and specifying proficiency levels.

Identification and delineation of subtasks are critical in the task analysis process, and this area received substantial treatment in the DeVries study. It was concluded that a subtask has all of the characteristics of a task except independence. Each task is independent of other tasks, but each subtask is dependent upon other subtasks. A subtask essentially does not exist outside of the group of subtasks that make up a task. Tasks are usually not components of a procedure, but subtasks are always components of a procedure. Subtasks are important for the instructional designer who is preparing detailed and meaningful instruction. In identifying subtasks, one must determine whether or not there is a logical breakdown of the task, and whether the subtasks can be measured, and must be able to develop a clear statement of all steps needed to perform the task.

The two best methods or techniques used in the identification of subtasks are task observation and document study. It is recommended that in the process of identifying subtasks which comprise a procedural task, it is often useful to observe a subject-matter specialist performing the task under either simulated or actual job performance conditions. Ideally task observation should take place in the job environment. The task observer

should list the steps required and indicate how the steps are performed. Document study should use the following steps: (1) select the documents to be used; (2) review all documents for content, sequencing and relevant technical data; (3) become knowledgeable of terminology; and (4) sort selected documents according to the types of information. The selected documents should include information such as system requirements and functions data; listings of duties, tasks, and subtasks; task data; descriptions of task activities and performance standards; and listings of supporting skills and knowledges.

The Task Analysis Handbook by DeVries, et. al. (1980) contains diagrams, tables, charts, and lists which make knowledge of procedures readily available in an illustrated manner. Particularly useful are the following procedures or processes which are illustrated in the handbook: (1) the ISD model; (2) hierarchy of performances, titles, and definitions; (3) STS/CTS proficiency levels; (4) task analysis process; (5) behavioral statement list form; (6) verb forms for task performance items; (7) verbs for each types of knowledge item; (8) types of conditions for preliminary performance ratings; (9) standards for preliminary performance ratings; (10) sample task diagram of a fixed sequence procedural task; (11) sample task diagram of variable sequence procedural task; (12) sample chart of documents used for document study; (13) appropriate and inappropriate levels of detail for specifying subtasks; (14) sample of task observation results; (15) a complete sample of a task diagram of a fixed sequence procedural task; (16) types of physical skills; (17) types of manipulative skills; (18) types of supporting knowledges; (19) a task diagram of a fixed sequence, oriented task; (20) a task analysis documentation form; (21) a task diagram of a variable sequence, nonequipment oriented task; (22) a completed task analysis documentation form of a variable sequence, nonequipment-oriented task; (23) a task diagram of a variable sequence, equipment-oriented task.

Instructor/Operator Console

Research indicates that many flight simulator consoles in use today were not designed according to the task analysis procedures described in this study. Some of the design requirements were established by subjective opinion, past experience, and space and equipment constraints. The

improvement of simulation quality and pilot training is related to instructor facilities.

Task analysis procedures may be used in the improvement of IOCs by the use of the following methods: (1) delineation of the instructional tasks and activities; (2) construction of a typical sequence of instructional tasks; (3) definition of typical instructor tasks or activities and a breakdown of those tasks in terms of units of time required for completion; and (4) incorporation of student learning activities into an integrated student oriented syllabus.

The study by Gray, Chun, Warner, and Eubanks (1981) is a model of some advanced techniques using principles of task analysis. Some of the design concepts of the model are contained in the following materials which were found particularly useful: (1) A-10 Instructional and Operational Task Capability Outline, (2) Instructional Support Feature Inventory, (3) Instructional Support Feature Survey Elements, (4) Survey Elements Unique to Certain Features, (5) Instructor/Operator Station Design, (6) Device Operations. The IOC was designed to simplify operational requirements and provide maximum A-10 training capability. With a minimal amount of training, the instructor pilot (IP) can provide the operator functions and the training functions. The A-10 IOC was designed to accommodate one person, the IP. Proposed utilitarian factors and design features will cause further adjustments relative to the location of the console. Further developments in automation will also have an effect on IOC design.

IV. Application of Task Analytic Techniques

The design and use of an IOC are related to functions of the instructor, the student, instructional support features, and training tasks. Specific areas in which task analysis techniques can be used include individualization of instruction; productive, economic and efficient use of student and instructor time; standardization of training; control of the simulated environment and aircraft conditions; diagnosis of student learning problems; focus of instruction; and provision for immediate feedback.

The task analytic techniques most adaptable to the IOC functions stated above would include a statement of preliminary performance requirements of a given task, identification of subtasks, identification of supporting skills and knowledges related to the subtasks, examination of training standards, conversion of task performance and task knowledge statements into behavioral requirements, documentation of preliminary performance requirements, task observation, and specification of proficiency levels.

Computer aided instruction (CAI) and computer managed instruction (CMI) have further possibilities in the future design of IOCs and computer applications make extensive use of task analysis techniques. SAINT (Systems Analysis of Integrated Network of Tasks) was developed at the Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio. SAINT is a model, in network form, of sets of tasks performed during the course of a mission. The following computer-based, automated activities have further implications for the application of task analytic techniques: automated adaptive training, automated demonstrations, automated coaching, automated controllers, automated cuing, automated performance measurement, and programmed mission scenarios.

Finally, task analytic processes emerge from a system; similarly, the instructor operator console should be designed using the ISD approach. Automation in pilot training will continue in the future; therefore, the efficiency and low-cost aspects of the task analytic process will justify its continued application in pilot training efforts.

V. Recommendations

Computer-based, multimedia, and individualized instructional systems have proved to be beneficial in military training. The application of task analytic techniques to the design of an instructor/operator console should thus continue to be an effective development effort. Continuation of this effort will yield substantial savings in training time and more efficient utilization of resources.

It is further recommended that another component, learner-controlled instruction (LCI), be added to the CAI/CMI-related instructor/operator console. The designation for the process would be the CAI/CMI/LCI Instructor/Operator Console. LCI is a method in which each learner develops his/her own sequence of learning. The LCI approach will need a great deal of study before it can be fully implemented in flight training.

The present capability of the instructor/operator console is adequate; yet, on the other hand, additional refinement could increase capability and cost effectiveness. The progressive development of the product is related to the ISD approach. According to Baker and Schutz (1971), one always has the next generation product underway before the current generation is developed.

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